FROST CURE.

In a measure frost injury to flower as well as to fruit may be cured by slow thawing. Probably it would be much more accurate to say that frost injury, at least in many cases, is caused rather by rapid thawing than by the original freeze; though it must be admitted that just how fruits, flowers and plants actually are injured by low temperatures is not perfectly understood. At any rate when fruit or flower is very slowly thawed out it often appears to be uninjured. Hence even after frost has covered an orchard it sometimes is possible, especially by the use of a heavy smudge on the windward side, so to shut off the morning sunshine and thereby so greatly to decrease the rate of thawing that but little injury follows. Clearly, though, this is a risky practice. It is another case where the old adage, "an ounce of prevention is better than a pound of cure," applies with full force.

CONCLUSION.

The most important thing in relation to frost protection is the proper adaptation to each other, at the time of planting, of fruit, climate, and location, with reference especially to time of flowering, probable dates of latest and earliest killing frosts, and freedom of air drainage. In this way natural frost immunity may generally be secured.

In places not so favored artificial heating often may be used on a large scale and with commercial success to prevent frost, the strong temperature inversion of a frosty night serving as a ceiling that restricts the heating to a thin surface layer of the atmosphere, provided, of course, that the heating is diffuse and the temperature of the air raised only a few degrees.

The meteorological principles and the physical laws involved in the problem of frost protection seem reasonably clear, but the question of economy introduces so many and such uncertain factors that its commercial practice must be difficult if not impossible completely to standardize. The best practice at one place and under one set of conditions presumably will differ in detail and may even differ in method from that of some other place under other conditions. To each region, and even to each orchard, pertains its own problem, which rational or scientifically guided experimentation alone can approximately solve.

In closing I wish to thank Mr. J. W. Garthwaite, of Corona, Cal., for his kindness in reading the manuscript of this article and for his generosity in putting several valuable suggestions at my disposal.

II.

UTILIZATION OF FROST WARNINGS IN THE CITRUS REGION NEAR LOS ANGELES, CAL.

By FORD A. CARPENTER, Local Forecaster.

[Dated Weather Bureau, Los Angeles, Cal., Jan. 22, 1914.]

CONTENTS.

(*a*) *Introduction.*—For 20 years or more oranges and lemons have been successfully raised in southern California, but it is only within the past decade that strictly scientific and up-to-date methods have been used in raising and selling the citrus products.[1] This has brought about a standardization of both the fruit and the marketing. Improved and more expensive methods of preparing the land, irrigating it, and planting with high-grade stock, as well as constant vigilance in fumigating and spraying for fruit pests, have necessitated better facilities for packing, handling, and selling the product. The frost menace made its first appearance in 1896, when some regions escaped without serious damage. The orchardists in the frosted localities immediately began experimenting with various preventives, thus antedating the frost protective work of the deciduous fruit growers in Colorado, Washington, and Oregon. The frost of two years ago increased the number of heating appliances, and the severe freeze of last year brought the entire industry in all portions of California face to face with an added hazard. It has been said that the freeze of 1913 raised a new crop of prevaricators, which may be divided into two classes—those who claimed that their district was frostless and others who declared that their district suffered destruction. A year has passed, and it is not too optimistic to say that the truth is a little nearer the former than the latter. Those orchardists who, anticipating severe frosts, had provided themselves with artificial heating devices realized handsomely on their additional investment, for the short crop of oranges, lemons, and grapefruit brought excellent prices. Fruit growers in the citrus region of California now add to their fixed expense account a liberal allowance for oil or coal pots, storage of fuel, instrumental equipment, and quarters for emergency labor. One million approved oil pots are now scattered over the citrus region in southern California.

It is the object of this memorandum report to give a brief description of the character of the country, its elevation and configuration, the variation in the exposure to sunshine and wind, and the variations in temperature that are caused by local environment. It is proposed to treat very briefly the distribution of lemons and oranges in differing climatic areas. Weather conditions causing frost will be briefly discussed. The manner in which warnings are issued by the local office of the Weather Bureau at Los Angeles, and how they are utilized by the fruit growers in this district will be considered in detail,

[1] Citrus crops of California for 1913; annual estimate by the Riverside Daily Press, Jan. 20, 1914; reduced to percentage by F. A. Carpenter.

Counties.	Orange.	Lemon.
	Per cent.	*Per cent.*
Redlands district	12	0
Riverside	10	0
Pomona	12	6
Ontario	11	8
Azusa-Glendora	9	6
Orange	7	9
Highland	6	0
Covina	5	0
Placentia, Fullerton, Rialto	11	.....
Rialto, San Fernando	.....	6
Whittier, etc.	6	11
Ventura	5	15
San Fernando, Pasadena	4	.....
Rialto, San Fernando, etc.	.....	6
San Diego, etc.	2	.....
Pasadena, San Diego, etc.	.....	10
Corona	0	12
San Dimas	0	9
Santa Barbara	10	8
Totals	100	100
SUMMARY.		
Northern California	14	0
Southern California	86	100
Crops, respectively, by carloads	35,270	3,900

Total, 39,170 carloads, or about 80 per cent of normal.

illustrated by a number of photographs made especially for this report. The essentials of orchard heating devices will also be described.

(*b*) *Character of the country.*—The citrus district of the country adjacent to Los Angeles covers a thin crescent-shaped region, having Santa Barbara for one extreme and San Diego for the other, with the San Bernardino Mountains marking the eastern limits (see fig. 1). This territory covers about 200 miles northwest to southeast and 40 miles in width. Much of the coast region, while possessing the climate, does not have the requisite soil. In elevation this district ranges from tidewater to 1,000 feet above sea level. Although the exposure is to all points of the compass, relative regional advantages are determined by the configuration of the country.

(*c*) *Variations in grove location.*—Citrus groves are located with a western exposure on the coast near Santa Barbara (fig. 2), with a southern exposure at Santa Paula (fig. 4), a northern exposure at Corona (fig. 32), a western exposure in portions of Redlands and Riverside; valley locations in San Fernando (fig. 12), and on either side of river washes as at Fillmore (figs. 8, 9, and 10), and in the foothill district of Pasadena (fig. 14).

(*d*) *Variations in temperature caused by local environment.*—It is needless to state that these widely different exposures give varying temperature values. It is often the case that what promises to be a general frost will give orchard thermometer readings varying from 26° to 56° in this district. A descending wind over the San Bernardino Mountains, or a change from the land to the sea breeze at Santa Barbara, Santa Paula, Chula Vista, or other coast localities, will change the temperature as much as 15° in as many minutes. On the other hand, a sudden cessation of wind in the lower districts will check natural drainage and lower the temperature many degrees in a very short space of time. An interesting fact in connection with differing climatic features in this region is noticed in the transportation of lemons and grapefruit from the region where they are grown to the more even and cooler coast climate. Lemons grown on the warm hillsides in winter are frequently sent a hundred miles north for natural cold storage and curing.

(*e*) *Pressure conditions which cause frost in Los Angeles and vicinity.*—There are three varieties of pressure distribution that bring frost to this locality. Named in order of their frequency they may be considered as follows: First, well-marked and general high-pressure conditions prevailing over the entire coast, such, as for example, preceded the phenomenal freeze of January 5, 6, and 7, 1913. Second, the advent of a small but energetic high area to the coast south of Point Conception. The formation of this area has to be carefully watched. It will frequently impinge on the coast in the vicinity of Los Angeles. If another high area happens to be in control of the weather over the western half of the country, this southern area will aid in the extension of the attendant northern low area, with accompanying gradients, resulting in heavy local rain. The southern high will then drift eastward, after the northern low moves northeastward, and it is then that the sky clears and strong radiation ensues, producing frost in the citrus region.

A third condition, and one that sometimes brings unexpected cold, is when an immense continental high is apparently too far to the eastward to affect the temperatures, but a slight weakening of the northwestern low area will allow the influence of the high to be felt by causing a sudden fall in temperature. The last-named condition obtained on the only occasion when emergency long-distance frost warnings have been issued during the present month. These warnings were issued from the Los Angeles office on the evening of the 12th to all citrus districts in the vicinity. Temperatures of freezing were generally reported the next morning. Pomona reported 27°F., Riverside 32°, and San Bernardino 26°, which were the lowest of the season of 1913–14 up to the present date (Jan. 22, 1914).

(*f*) *How frost warnings are issued from the Los Angeles office.*—Warnings of frost are worded according to their expected severity such as "light frost in exposed places," "light frost," "heavy frost in lower levels," "heavy frost," "severe frost," "killing frost," "killing frost; growers should fire early." These warnings are printed on forecast cards and on the maps and mailed at half-past 9 a. m. to about a thousand addresses. The 11 a. m. and later editions of the evening papers print regular weather "stories" during the season, in which the local forecaster is quoted in full, and generally with much accuracy. The largest long-distance-telephone company distributes the morning forecasts free of charge to every "central" telephone office in southern California, so that every grower can secure the morning weather report. Special long-distance warnings are sent to responsible distributing centers in all districts north of Escondido, (1) when the morning forecast happens to be too late for the mails, (2) when evening conditions have changed making a special additional warning necessary.

(*g*) *Utilization of frost warnings.*—The cooperative associations throughout this district have such an excellent system that all information received from the Los Angeles office is immediately put to the best use.[2]

Individual growers depend to a great extent on the official warnings, although all have their own alarm thermometers and instrumental equipment which in addition allows them to amplify the warning. The writer happened to be at a large citrus headquarters when a frost warning was received The military exactness and promptitude of the association in delivering and executing orders for the "firing squad" (fig. 5) gave evidence of the successful working out of a splendid system. In all districts nothing is now left to chance; the management of the majority of the big orchards reminds a visitor of the scientific accuracy observed in a Government agricultural experiment station. At Corona a checking-up system is employed for the benefit of local orchardists.

(*h*) *Orchard protection by heating devices.*—Where there is one coal basket in this district there are over 1,000 oil pots, so popular has become the oil system of heating. The plan is to place a 7-gallon oil pot to each tree, with a double row of pots around the exposed side of the grove. The improved down-draft pot (figs. 4, 6, and 32) will last from 6 to 10 years if given good care. It is very economical, as the fire can be regulated depending on the variation in air temperature. At Santa Paula it has been found that temperatures as low as 12° can be negotiated

[2] The following (fig. 16) is a sample of letters sent out by the lemon and orange associations in the Los Angeles district:

ONTARIO FROST PROTECTIVE LEAGUE.

ONTARIO, CAL., *December 6, 1913.*

SIR: Arrangements have been made with the U. S. Weather Bureau station at Los Angeles to telephone any special frost predictions that may be made in the afternoon or evening. The local telephone company have your name and these messages will at once be telephoned to you.

Whenever the temperature falls to 35° F. lemon growers will be notified in order that they may be on the alert to personally watch conditions.

Whenever the temperature reaches 29° any time before midnight orange growers will be warned. If the temperature reaches 32° at midnight and whenever it drops to 28° up to 4 o'clock a. m. orange growers will also be notified.

As a dangerous condition does not exist when there is much humidity in the air, even at these temperatures you will also be notified of this fact, and growers must then use their own good judgment whether to fire up or not.

As the telephone operator has to call up quickly a great many people, *please do not ask operator any questions* as she can tell you nothing more than the message she has been directed to give. *This is important.*

To face page 570.

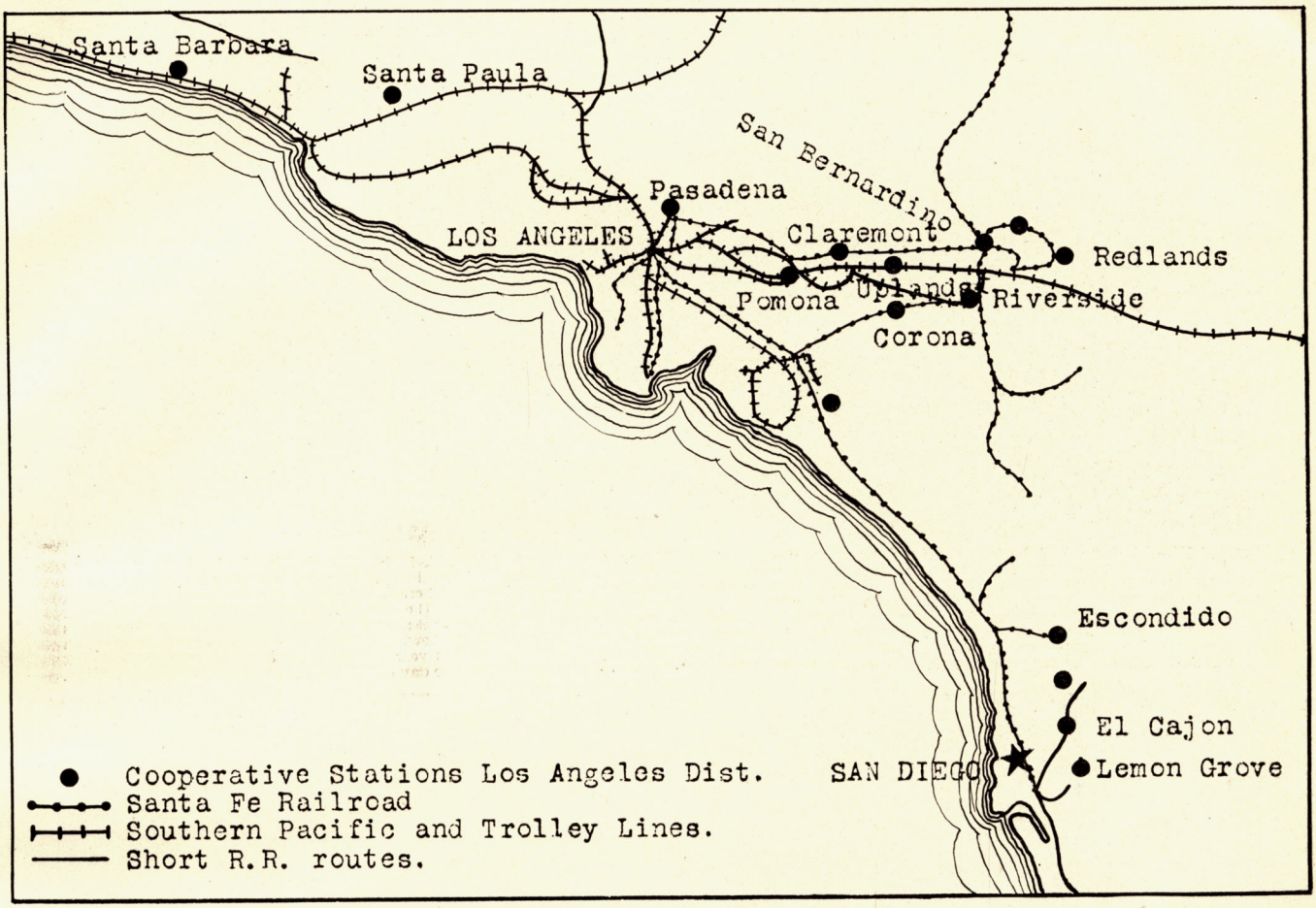
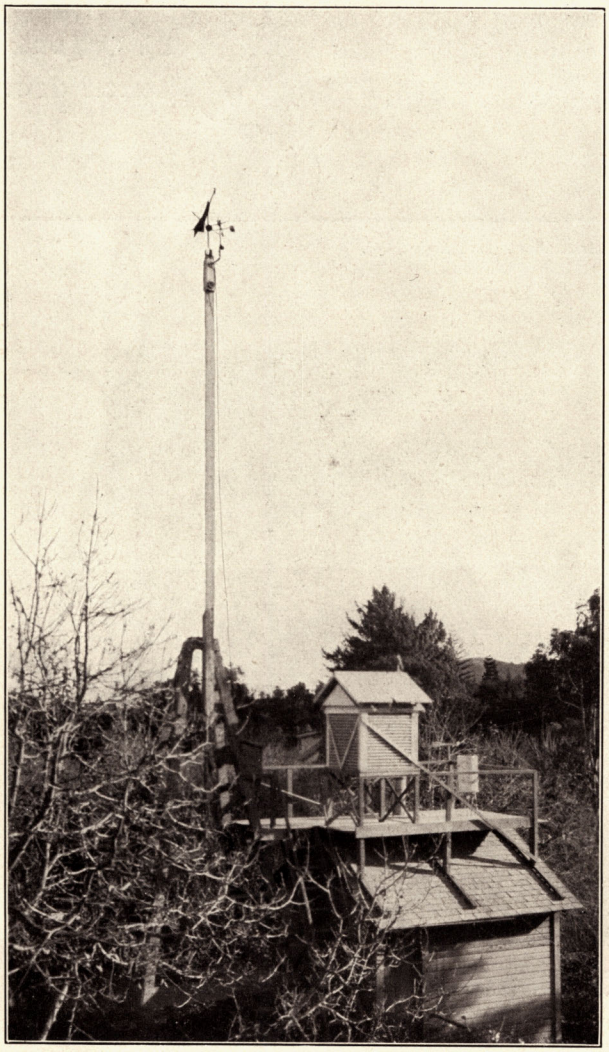


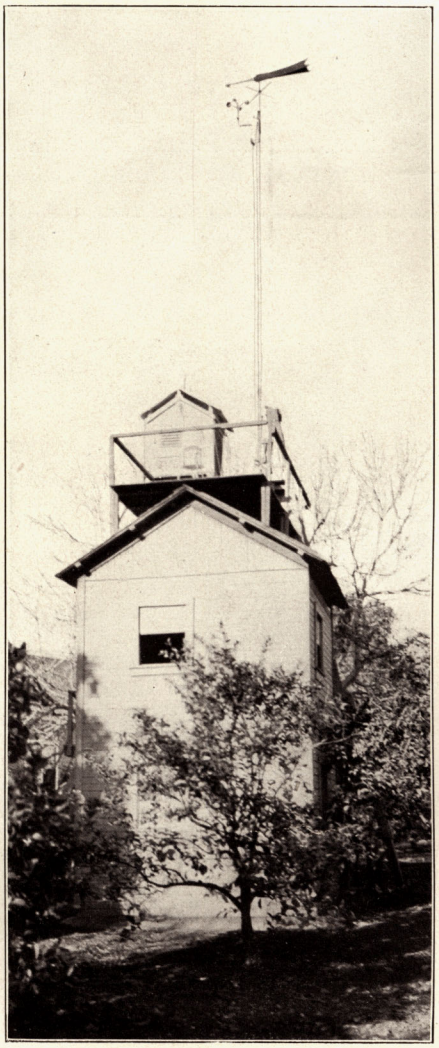
FIG. 1.—Map of the citrus fruits district about Los Angeles, Cal.

FIG. 2.—A typical Santa Barbara (Cal.) landscape. View is from the pergola of the Potter Country Club, looking toward the San Rafael range (6,500 feet). A lake is in the middle distance, the lemon groves are beyond the rounded oak-clad hills.

FIG. 3, § IV.—Photograph of the dust cloud accompanying "norther" conditions. (Photographed Mar. 16, 1914.) This depicts the birth of a "norther" in the Los Angeles district. This typical dust cloud always marks the beginning of "norther" conditions. The snow-capped peak in the center is Mount San Antonio (10,080 feet) and its range is about 25 miles distant, due north. The dust cloud, where it is beginning to reach ordinary intensity, is over the town of Pomona, Cal., which is about 16 miles distant. As the wind warms up to its work the long, horizontal streamer reaches the height shown in the northwestern portion of the photograph. Although the wind direction is from the east the western portion of the country first shows the dust cloud at its maximum density. The dust billow in the west [on the left of the center of this view] was raised in about one hour; in less than two hours the mountain range entirely disappeared. This condition has occurred very seldom this year (1914), but during the season of 1912–13 it was an almost continuous performance. Figure 4 on page 573 presents the station weather map on the day on which the above photograph was taken.



A.



B.

FIG. 3 A AND B.—Weather Bureau cooperative station at Santa Barbara, Cal. *A*, View of the station from a neighboring tower. This shows the anemometer, wind vane, instrument shelter, sunshine-recorder, and tipping bucket gage. *B*, A side view of the same station as seen from the ground. The thermometers in the shelter are 24 feet above the ground.

FIG. 4.—One of many orchard instrument shelters on the Lemoniera Ranch, Santa Paula, Cal. The thermograph in this instrument shelter read several degrees higher than thermometers attached to trees. Investigation showed the cause to be the proximity of the irrigation standpipe. In the shelter the temperature was 36° F.; on the ground near the trees, 30°; just inside the edge of the pipe seen standing near the supporting frame, 43°. The illustration also shows the method of using pots close together to protect the outside of the grove. The superintendent, Jas. D. Culbertson, writes: "During the season 1912-13 the expense of protection amounted to the following figures: Total investment for 500 acres, $91,225.92; cost of equipment, $182.45 per acre; annual deterioration and maintenance, $33.34 per acre. These figures do not include operating expenses."

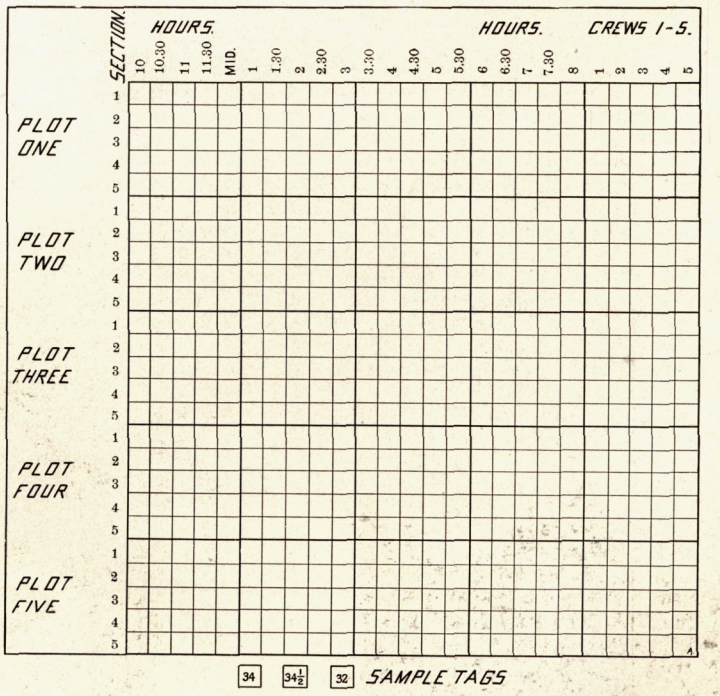


FIG. 5.—A "temperature board" for the Lemoniera orchards, designed by Foreman Perry, of the Lemoniera ranch. This blackboard chart is located at the ranch library. Columns show the hours from 10 p. m. to 8 a. m., divided into half hours. Horizontal divisions are plots and sections. Crew distribution is shown at the extreme right-hand edge of the chart. Cards bearing boldface printed figures in degrees and half degrees are hooked into the squares from which temperature reports have been received by telephone. If the temperatures approach 30° F. in any section, a firing squad is sent out and pots are lighted. Great importance is attached to firing early. The general experience in the Los Angeles citrus district shows that fuel and labor must not be spared in keeping the temperature from *reaching* the danger point.

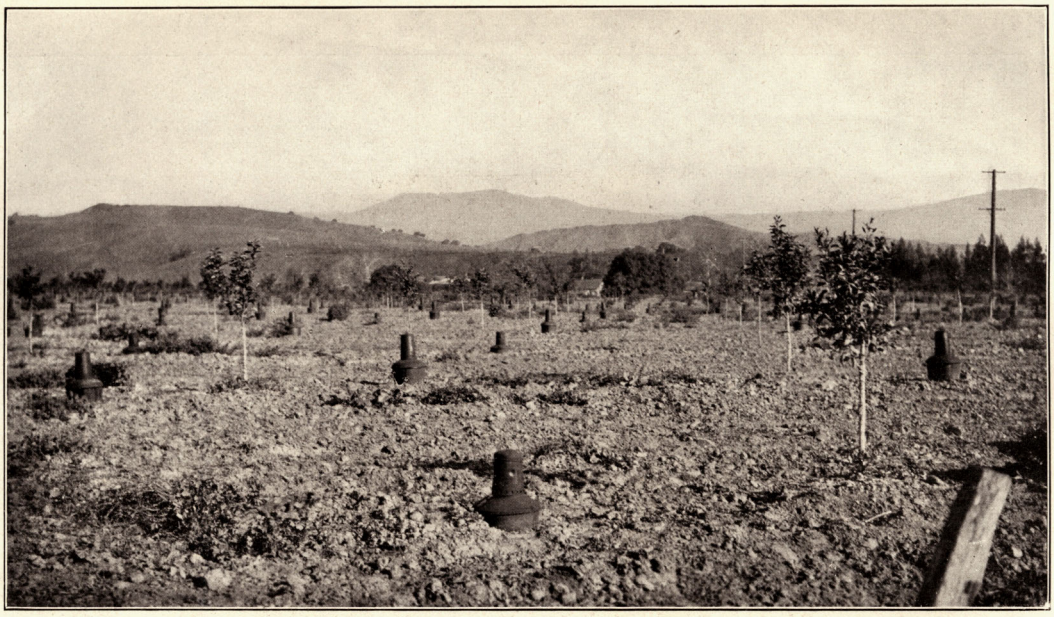


FIG. 6.—A young lemon grove at Santa Paula, Cal. This view shows the distribution of oil pots to protect the trees of a young lemon orchard. Each tree is protected by a pot having a capacity of 7 gallons of oil. The pot can be regulated to burn at the rates of 1 pint to 1 gallon per hour. This is the popular pot of this district. It costs $1.04, and will last, with care, 6 to 10 years. It is estimated that the equipment of the Lemoniera ranch will successfully cope with an outside temperature as low as 12° F.

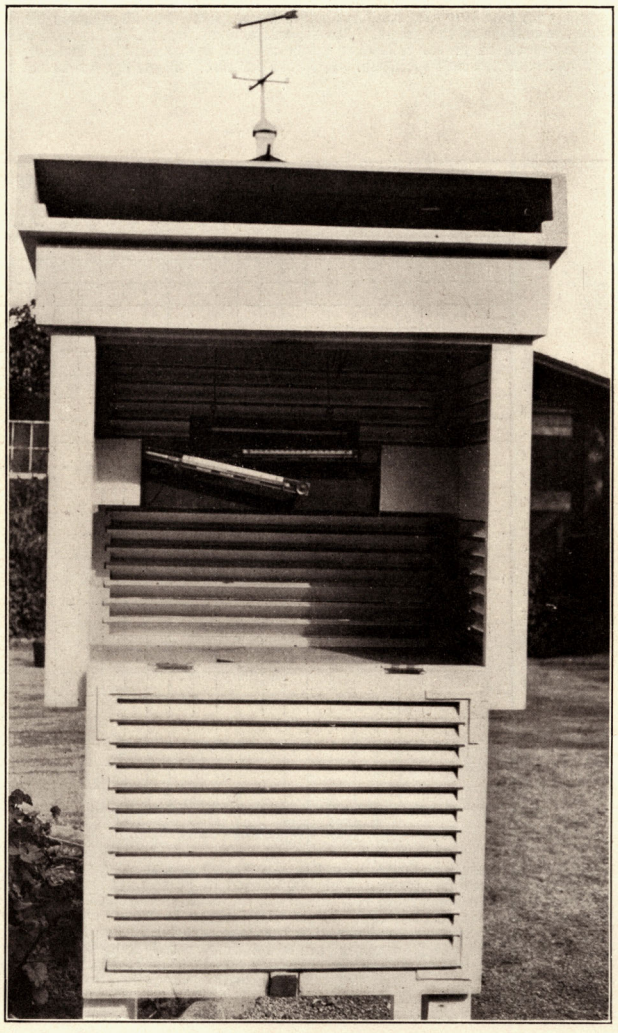


FIG. 7.—View of the instrument shelter (open) at Fillmore, Cal. This is one of perhaps a hundred such privately equipped thermometer shelters scattered over the citrus fruit region adjacent to Los Angeles, Cal.

To face page 570.

FIG. 8.—View of Fillmore Bridge. Orange groves are to be observed from the foothills to the edge of the river wash. The "wash" in this locality is wide and drains the greater portion of this citrus region. On the north slope of this valley growers are experimenting with glass coverings for several acres.

FIG. 9.—A lemon orchard at Fillmore, Cal. In the distance is seen the Topatopa Mountains. The old-style oil pots shown in this photograph carried this grove through safely and with but small expenditures of labor and oil. This was doubtless due to the excellently drained, extensive "wash."

FIG. 10.—Fillmore High School, set in an orange grove. It is not unusual in the citrus district to find schoolhouses in orange orchards. It is seldom, also, that orange or lemon groves are fenced off from the highway. [Figure omitted.]

FIG. 11.—Portion of the San Fernando Valley. Flat valley land not suited to citrus growth because of the nocturnal settling of cold air and the brisk winds of the day. This land, where planted, is largely in peaches and vegetables. [Figure omitted.

FIG. 12.—A lath house protecting the lemon nursery of T. J. Walker at San Fernando, Cal., in the upper San Fernando Valley. In this lath house temperatures average 4° F. higher than those in the unprotected orchard near by. Only a few fire pots are needed in the lath house.

FIG. 13.—Thermometer exposure at the Pasadena station, located in a deciduous fruit orchard, belong to Cooperative Observer E. R. Sorver, secretary of the Pasadena Board of Trade. [Figure omitted.]

FIG. 14.—Lemon grove in Pasadena, Cal. One of hundreds of 20-acre lemon groves owned and managed by retired professional men. Mount Wilson (5,000 feet) is in the background. [Figure omitted].

FIG. 15.—Lemon grove at Upland (Ontario district), Cal. A lemon grove of 40 acres a Upland. San Gabriel Mountains are in the distance. [Figure omitted.]

FIG. 16.—[See footnote 2, p. 570.]

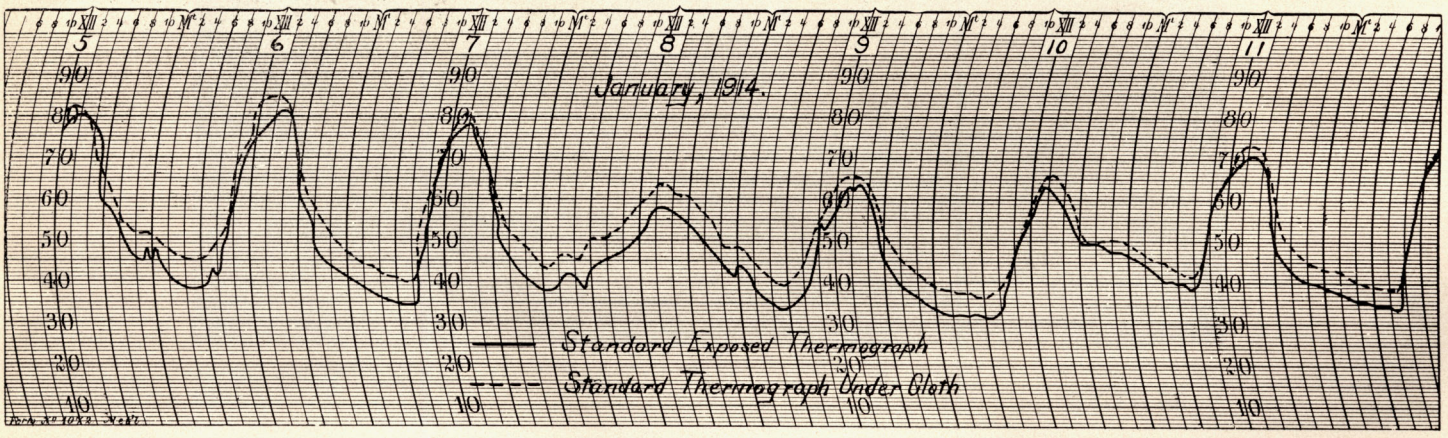


FIG. 17.—Thermograms (Richard) at the Pomona cooperative station, January 5–12, 1914. Cooperative Observer J. E. Adamson erected portable "horses" in a selected acre of his orchard and, with rollers, covered the tops of the trees. The material used was tobacco cloth; 5,000 yards of material were required. The cost of such protection was $265 for the acre. A standard Richard thermograph was exposed in a Weather Bureau standard cooperative shelter located in the center of this covered acre. The thermograms show the differences between the standard thermograph exposed in a shelter similar to that shown in figures 18 and 33.

FIG. 18.—Thermometer exposure at Pomona, Cal. One of a number of thermometer shelters at Cooperative Observer J. E. Adamson's orchards. [Figure omitted.]

To face page 570.

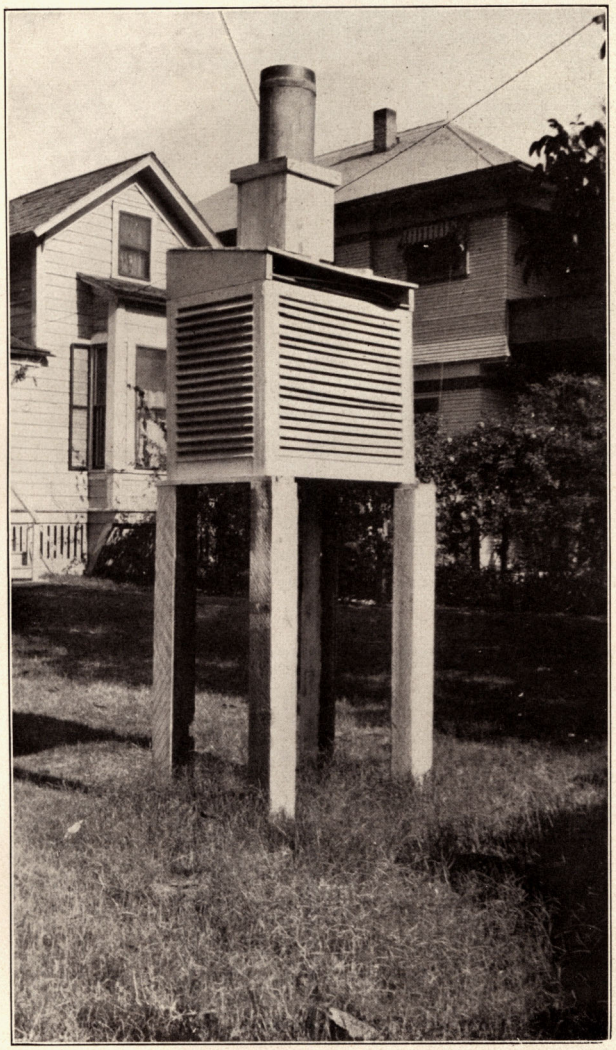


FIG. 19.—Thermometer exposure at San Bernardino, Cal. This shelter is located among a few orange trees in the back garden of Cooperative Observer Dr. A. K. Johnson. It will be noted that the rain gage is on the roof of the shelter "to prevent interference."
[This illustration is reproduced to show how the rain gage should *not* be exposed. The gage should be installed *on the ground* and all interference otherwise prevented.—C. F. M.]

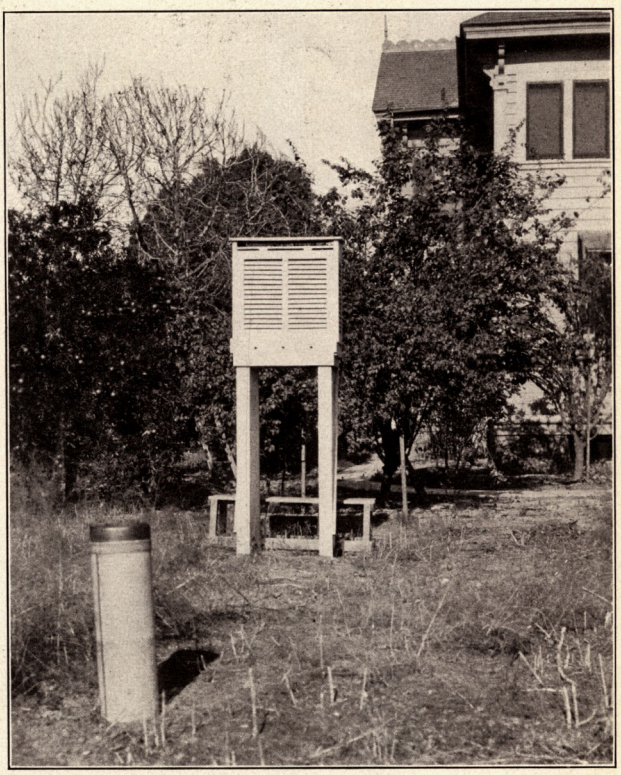


FIG. 21.—Thermometer exposure at Riverside, Cal. The thermometer shelter and rain gage of the cooperative observer.
[This shows a proper exposure for the rain gage.—C. F. M.]

FIG. 20.—Thermometer exposure at Redlands, Cal. This shelter is in a marble-cutter's sales yard in the business portion of the city. It is across the street from the place of business of Cooperative Observer Hargraves, city editor of the "Redland Facts."
[Figure omitted.]

To face page 570.

FIG. 22.—Lemon picking, January, 1914, at Whittier, Cal. Lemons are picked throughout the year, as the trees are continually bearing. Size alone determines the conditions for picking. Special attention is drawn to the tips marked by asterisks (*). These show the effect of the high, drying winds of December, 1912. All the leaves were stripped from the shoots by the desiccating action of the "norther." The new growth will be seen to be rich and abundant. Mr. G. Harold Powell estimates that the drying winds that preceded the freeze of 1913 were responsible for probably 50 per cent of the damage to last season's citrus crop.

FIG. 23.—Coal baskets on the Leffingwell ranch. This orchard, in the ideally located lemon district of Whittier, Cal., uses coal baskets with a capacity of 18 pounds of soft coal. The baskets burn for seven or eight hours and have the serious disadvantage that their heating can not be regulated. Once fired the basket must burn for seven or eight hours until its contents are consumed. It is claimed that the expense of maintenance of the coal basket is offset by its greater cleanliness and the freedom from soil damage. Soil experts state that oil leakage does lasting damage to the soil; however, nine-tenths of the orchard-heating devices use oil.

FIG. 24.—"Overhead wiring" system of the Rudesill orchard, Corona, Cal., seen from overhead. The inventor, Mr. Rudesill, claims that "the telegraph wires used would conduct the cold away from his grove and bring the heat to it." He claims to have observed that the temperatures were 2° higher under the "wire-protected" region than outside this area. This is the only instance of misdirected effort found among the hundreds of groves visited. [Figure omitted.]

FIG. 25.—Meteorological instruments at the Sias ranch, Corona, Cal. The Sias orchard stand, with recording maximum and minimum thermometer and the rain gage, are located in the back garden of the Sias residence, which is within a large lemon grove. [Figure omitted.]

FIG. 26.—Natural drainage by an arroyo at Corona, Cal. The arroyo at the right drains a great portion of the Corona lemon district of cold air. Observations show an inversion of from 14° to 18°. Further experiments as to the change in temperature with wind direction and velocity and under varying moisture conditions will be carried on by Cooperative Observer J. E. Garthwaite. [Figure omitted.]

To face page 570.

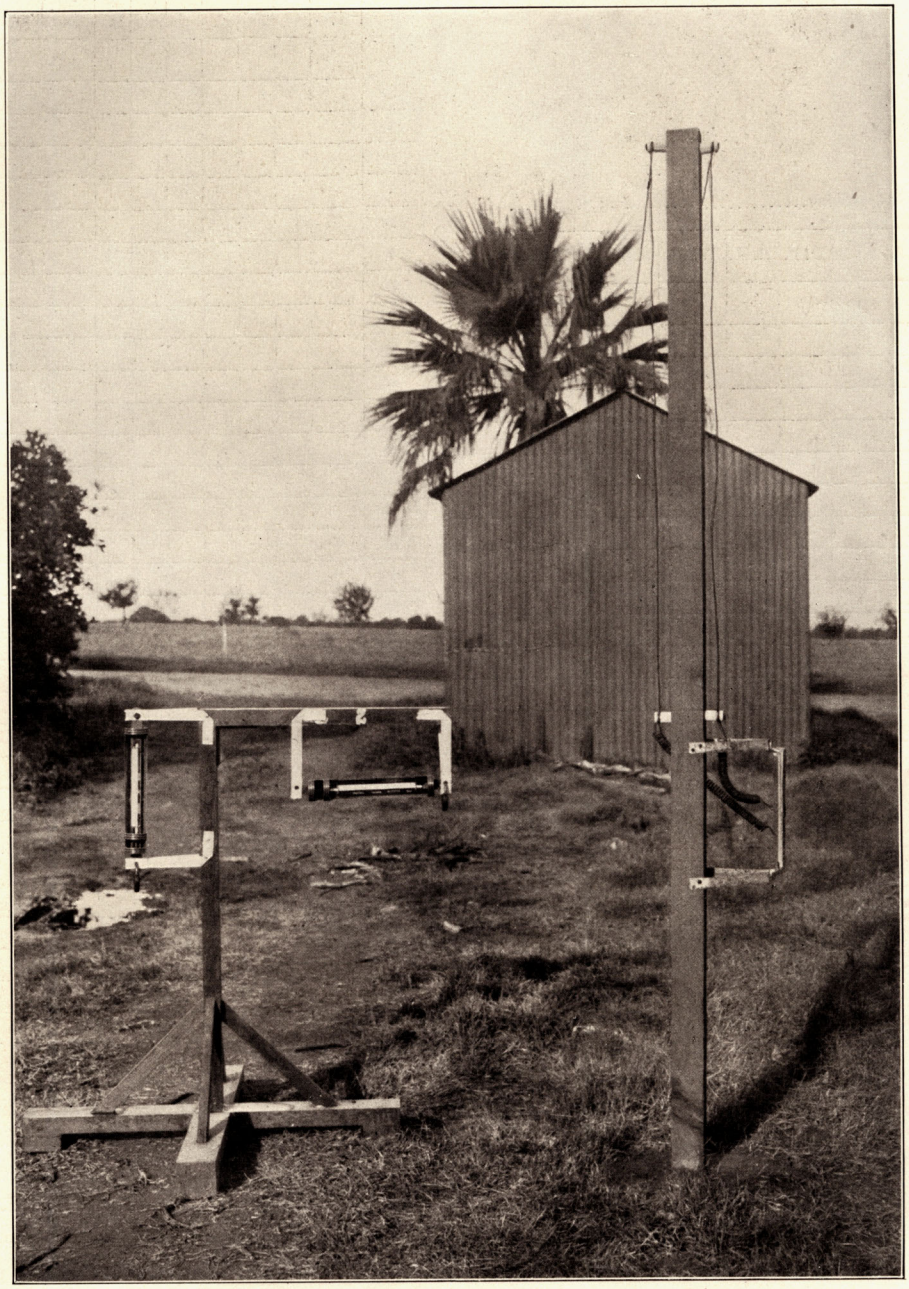


FIG. 27.—Orchard thermometers, recording minimum thermometer, alarm thermometer, and their supports. Garthwaite groves at Corona, Cal. [Photo by Garthwaite.]

W F 32 3. 28

Winter weather records. Night beginning..... Lowest min.....

	1	2	3	4	5	6	7	8	9	10	D. P.	R. H.	Wind.	Sky.	Remarks.
4															
5															
6															
7															
8															
9															
Min.															Temperatures taken in open 3 feet above ground.

FIG. 28.—Card for weather records; from the card system in use by the Corona Lemon Co. Designed by J. E. Garthwaite, manager. The abbreviations on the card have the following meanings: W=Watchman (steel tag). F=Fired. A yellow tag indicates a Weather Bureau warning received at the time it gives. A white tag on the figures 28, 30, or 32 indicates the temperature. Vertical columns headed 1, 2, 3, etc., indicate hours. Horizontal lines numbered 4, 5, 6, etc., indicate the sections of the protected region to which the entries apply.

Watchman's report.

Night of....., 191... Watchman.....

Time.	Temperature. Station 1.	2.	3.	4.	5.	6.	Alarm.	Help called.	Weather changes (mark time of appearance of frost, dew, cloud, wind, or wind changes, fog, rain).	Pots lighted (give number of pots lighted or extinguished at any time; give damper changes).
5										
30										
6										
30										
7										
30										
8										
30										
9										
30										
10										
30										
11										
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3										
30										
4										
30										
5										
30										
6										
30										
7										
30										
8										
Min.							Remarks:			

Make all marks at nearest half hour.

FIG. 29.—Watchman's report blank, in the warning system used by the Corona Protective League, J. E. Garthwaite, manager.

FIG. 30.—Testing orchard thermometers. A dozen orchard recording minimum thermometers and stands in process of hourly tests during a cloudy day. It was pointed out to the designer, Mr. Garthwaite, that he had made no provision for the accumulation of dew or moisture on the thermometer bulbs which would naturally give him erroneous readings even with a light wind blowing. It was suggested that this fault could be remedied by attaching a simple shade over the thermometer. [Figure omitted.]

To face page 570.

FIG. 31A.—Alarm thermometer and mounting in orchard at Corona, Cal. This alarm thermometer is one of the closed-circuit variety. A drop to critical temperatures breaks the circuit, opens a relay and operates an alarm in the watchman's quarters. The photograph also shows the rank growth of the "cover crop" carefully cultivated in the lemon groves. When this growth attains its maximum height it is plowed under; thus humus material is supplied to the soil. [Fig. 31B, omitted.]

To face page 570.

FIG. 32.—Approved oil pots as they are distributed in the Corona groves. The oil pots are shown with the tops removed, thus the lighting and filling devices are visible. Each pot in this district is seated on a concrete slab, regularly inspected for rust spots, and varnished often. The average smudging period in Corona for lemons is December 10 to March 10. During the past season (1913–14) oil pots were lighted on 27 nights.

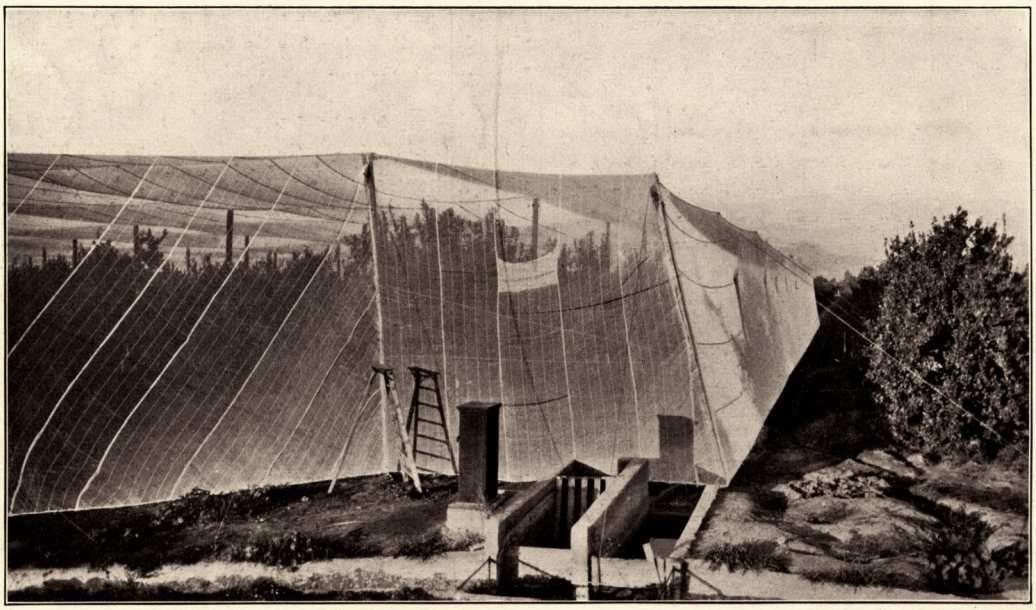

FIG. 33.—A 5-acre lemon orchard under cloth, Corona, Cal. Experienced lemon growers think that while this method might be a great advantage in protecting against scarring by high winds (if the latter do not destroy the covering fabric), yet the expense of $200 per acre would not justify its use for checking radiation. During one week the daily minimum under the covering averaged 4° F. higher than the outside minimum. (See fig. 17.)

safely. Protection by oil pots is an expensive undertaking, the cost of equipment per acre being in excess of $180, with $33 for maintenance and deterioration. Cost of labor and oil would be additional. Coal baskets are favored by an inconsiderable number of orchardists. There is one feature in their favor, and this is that there is no oil leakage in the grove. Oil drippings in the groves are detrimental to the trees, so that great care has to be exercised to prevent such damage. The piping of fuel oil and the use of burners is thought to be impracticable for the reason that it is difficult to obtain a good pipe joint, and the leakage then being so near the roots would injure the trees. Various systems of covering the groves have been tried, cloth in Pomona (fig. 17) and Corona (fig. 33), lath at San Fernando (fig. 12), and glass at Fillmore (note on fig. 8). The only available thermograph records as to temperatures within and without an orchard covering have been made by Cooperative Observer J. E. Adamson, of Pomona. Traces of thermograms are reproduced in figure 17. It was found that the minimum temperature within the inclosed portion of the grove was from 2° to 8° higher than the outside minimum, and that during warm days the minimum within the inclosure was also from 3° to 4° warmer than outside. The experiments have not proved satisfactory to those who have conducted them. The experimenters feel that some sort of covering is desirable to protect from the drying winds as well as from the cold, but the ideal shelter is yet to be constructed. In this, and in all other lines, intelligence of a high order has been brought to bear on the many problems constantly confronting the citrus orchardist. For example, elaborate thermometer tests are carried out in scores of orchards (fig. 30), air-drainage observations are being made (fig. 26), and only once during his visits did the writer find an instance of misdirected effort (fig. 24).

(*i*) *Necessity of closer relations between orchardists and the Weather Bureau.*—The orchardists appreciate the aid given them by the Weather Bureau. Being intelligent men, they realize the limitations of the endeavors made to serve them. They do not ask the impossible. In closing this report it is suggested that efforts be continued along the lines of more specific forecasts, including in the frost warning more than the mere statement that frost is expected. It is desired that, when possible, probable relative humidity values be included, as well as other pertinent information. Forecasts as to the drying winds of late autumn, winter, and early spring (fig. 22) would also be valuable as additional protection and in planning irrigation.

In conclusion it may be stated that there is a unanimous desire for closer relationship, leading to helpful cooperation, between the orchardists and the bureau.

III.

LETTER ON FROST AND FROST PREVENTION.

By J. W. GARTHWAITE, Manager.

[Dated Corona, Cal., Feb. 4, 1914.]

I have been through Prof. Humphreys's very interesting paper [see above, p. 562] with great care and feel that from a general point of view he has covered the subject extremely well. From the standpoint of the citrus grower I may offer a few suggestions.

We have all had a general understanding that, as Prof. Humphreys says, the temperature of the air a few feet above the ground will be found a good deal higher than that at the surface. The results of the freezes of December, 1911, and January, 1913, were such as to indicate that, in this section at least, damage was general in all parts of the trees; in some cases seeming to have been more severe at the top. This condition could be accounted for by the fact that there is often more tender growth at the top than in other parts of the tree. Of course in many orchards all the fruit was frozen, regardless of location; but in such as were more fortunate the good fruit was not to be found more on the higher branches than on the lower, but rather where the particular piece of fruit was protected by a covering leaf or branch. However, these two freezes are probably not to be taken as typical, since they did more damage to high ground than low; but as they are the only freezes that have done serious damage in this section they are the only ones that I can cite.

The well-recognized frost indications of which he speaks do not seem to be reliable in this district. For instance, a low temperature at 8 p. m. is very often a false alarm, while a high thermometer at the same time in the evening is often followed by frost. A clear sky is, of course, a bad sign; also a few times this winter I have retired feeling that all was lovely because of clouds or even a dense fog, only to be awakened at some cruel and unusual hour by the frost alarm to find clouds or fog gone the way of all flesh. And the same thing applies to wind. At no time this winter have I observed a dew point below 36°F., and yet on 19 nights the temperature has dropped to 32°F., or lower. On December 28, 1913, the dew point at 5 p. m. was 48°; at 6 p. m. it was 46°; at 8 p. m., with the temperature at 40°F., I found dew forming; at 10 p. m., with the temperature at 42°F., I found that the dew had disappeared and the dew point was 41°; at 3 a. m. dew began again to form at 33°; the minimum was 30°F. This is a fair sample of the way the humidity behaves in this benighted region. These facts probably account for the very frequent finding of frozen dew here.

The keeping of the ground clear and rolled, as suggested, is not practical in most citrus districts, owing to the necessity of growing humus crops and that of winter irrigation during seasons of insufficient rain.

Prof. Humphreys suggests the possibility of building a wall or growing a close hedge to prevent the setting in of cold air, and this calls to mind the fact that last winter many orchards were saved by eucalyptus wind-breaks on the north side. This was due, no doubt, to the fact that a great deal of the damage was done by a cold heavy gale from the north.

The objection that spraying trees with water would injure the bloom by washing away the pollen would not seem to be a consideration in the case of citrus trees; no damage ever having been noted after spraying, with all kinds of chemicals, during the blooming season even under pressure of from 175 to 200 pounds and perhaps higher. Such spraying is practiced about San Diego at all times of the year. And was reported by the writer last spring for the control of red spider.

Under the head of irrigation there are one or two points which it might be well to consider. In the central part of the State, and probably in other parts as well, a great many growers seem to have all the water they need from deep wells, which on a frosty night would be considered quite warm. This water would seem to be available at all times and so might be useful. In general, however, there is no doubt that Prof. Humphreys is right in objecting to this means of preventing frost. However,